Recovery of Critical Energy Materials from Industrial Geothermal Plant Brines - DOE FOA NUMBER: DE-FOA-001376

Qualifications, Experience, and Capabilities of the Project Team:

The technical plan proposed will be executed by CSM, as the lead organization, and NREL. CSM will lead the majority of the experimental evaluations. The assessment of the economic potential of the proposed mineral recovery process and some experimental tests will be performed at NREL. Energy Source LLC will provide the brine from its geothermal plant and offer in kind technical support.

The proposed work will draw on a highly qualified team with multidisciplinary expertise in extractive metallurgy (hydrometallurgy, pyrometallurgy, electrometallurgy, and chemical processing), high temperature corrosion, heat transfer, cost analysis, and material science to address fundamental issues related to mineral recovery extraction technologies. With our team's unique expertise and capability, we will optimize the efforts to meet the technoeconomic goals and thus make geothermal technologies cost competitive with other energy sources. By teaming with recognized experts from both NREL and Energy Source LLC of the geothermal industry, CSM will position the project to a low-risk, transformative and innovative technological solution for commercial mineral recovery technologies. Prof. Corby Anderson (PI-CSM) will lead the efforts. He has over 36 years of global experience in industrial operations, management, engineering, design, consulting, teaching, research and professional service. His career includes positions with Morton Thiokol, Key Tronic Corporation, Sunshine Mining and Refining Company, H. A Simons Ltd. and at CAMP- Montana Tech. He holds a BSc in Chemical Engineering from Montana State University and an MSc from Montana Tech in Metallurgical Engineering and PhD from the University of Idaho in Mining Engineering - Metallurgy. He is a Fellow of both the Institution of Chemical Engineers and of the Institute of Materials, Minerals and Mining. He holds ten international patents and six new patent applications covering several innovative technologies, two of which were successfully reduced to industrial practice. He currently serves as the Harrison Western Professor in the Kroll Institute for Extractive Metallurgy as part of the George S. Ansell Department of Metallurgical and Materials Engineering at the Colorado School of Mines. In 2009 he was honored by the Society for Mining Metallurgy and Exploration with the Milton E. Wadsworth Extractive Metallurgy Award for his contributions in hydrometallurgical research. In 2015 he was awarded the International Precious Metals Institute's Tanaka Distinguished Achievement Award. In 2016 he will receive the Distinguished Member Award from the Society for Mining, Metallurgy and Exploration. In 2017 he will receive the EPD Distinguished Lecturer Award from The Minerals, Metals and Materials Society.

Prof. Patrick (Pat) Taylor (CoPI-CSM) will serve as the Co PI. He joined CSM in the summer of 2002 after being named the George S. Ansell Distinguished Professor of Chemical Metallurgy. Previously he was the Fred N. Peebles Professor and Head of the Department of Materials

Science and Engineering at The University of Tennessee. Prior to that he was at the University of Idaho where he was Professor of Metallurgical Engineering and Head of the Department of Materials, Metallurgical, Mining and Geological Engineering. He has supervised research for more than 50 graduate students, published over 125 papers and received six patents.

Mr. Eric Spomer, President and Mr. Derek Benson, Vice President of Business Development representing Energy Source LLC will also be a key part of the technical team. Energy Source is a leader in its use of the best available technology for generating geothermal energy. The company bases its development activities on the Salton Sea geothermal resource, one of the most productive geothermal resources in the United States. The John L. Featherstone Plant is a three-stage flash geothermal power generating facility. It is the first new stand-alone geothermal power plant constructed in the Salton Sea resource in more than 20 years.

The Featherstone Plant is now selling its power pursuant to a 30-year power purchase agreement with Salt River Project, a municipal power and irrigation district in Tempe, Ariz.

Mr. John Featherstone has worked in the geothermal industry continuously since 1973. The major portion of his experience has been at the Salton Sea Geothermal Field in the Imperial Valley of California. He also has worked at the East Mesa Field in Imperial Valley and at geothermal fields in the Philippines and Indonesia. As Senior Vice President of Operations and Engineering for EnergySource, Mr. Featherstone was instrumental in all phases of the successful 55 MW Featherstone plant at the Salton Sea Geothermal Field. He is the inventor of the crystallizer/clarifier process utilized for scale control of the Salton Sea Field. He was also instrumental in a second scale control method that utilizes hydrochloric acid to retard silica deposits in geothermal systems. Mr. Featherstone was heavily involved in CalEnergy's Zinc Extraction efforts at the Salton Sea Geothermal Field. He is the named inventor of forty-two (42) U.S. and foreign geothermal related patents and is currently the Chief Technical Officer for EnergySource LLC.

Ms. Anna Wall, Energy Technologies Analyst at NREL, will be in charge of the economic potential assessment analysis of the proposed mineral recovery process. Her professional experience includes technical consulting on water geochemistry for the federal EPA Office of Water and data product development for financial services. Her master's in geochemistry involved field study of geochemical mixing signatures in a geothermal system for mineral carbon sequestration. She is currently pursuing a Master of Business Administration degree with concentrations in analytical finance, strategic management, and economics, which she expects to receive in June 2016.

Dr. Judith Gomez, Materials Engineer IV at NREL and Assistant Research Professor in the Metallurgical & Materials Engineering Department at CSM, has nearly 20 years of experience in extractive metallurgy focused on chemical processing of materials. Dr. Gomez holds a patent related with a high temperature extraction process to produce elemental boron. Her understanding of high-temperature systems and chemical interactions in corrosive environments salts, such as molten salts and supercritical CO_2, will be invaluable to the development of statistical models relating sampled geochemical relationships to blind resources.

Concept Paper **DE-FOA-0001376**

Dr. Craig Turchi at NREL is a systems analyst that provides support to NREL's geothermal group. He will support the techno-economic assessment analysis. He currently leads a geothermal system analysis task, which is responsible for estimating the cost and impact of geothermal technologies.

Facilities

CSM has access to extensive state-of-the-art mineral processing, extractive metallurgy and analytical equipment. CSM is also part of the DOE Critical Materials Institute with Dr. Roderick Eggert representing CSM in this nation wide hub.

NREL not only has the capabilities to perform basic research, but also has highly qualified scientific staff. NREL is recognized as the expert in geothermal technologies with unique R&D equipment and expertise in: i) cost and systems analyses; iii) geothermal-related computational calculations; iii) process development; iv) materials testing and characterization; and v) heat transfer and fluid dynamics.